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Failure of two porous sandstones under true triaxial conditions

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ABSTRACT

The role of the intermediate principal stress in rock failure has been a subject of continuing debate since the pioneering work of Mogi in the 1960s with true triaxial tests. These are tests in which all three principal stresses are different, ,, positive in compression. In recent years, an increase in data from such tests, some at constant Lode angle and/or constant mean stress, has provided additional fodder for discussion. Here, we analyze the results of tests on true triaxial data from two porous sandstones, Coconino [1] and Bentheim [2]. The tests are of two types: conventional tests which are fixed and are increased to failure; and novel tests which are fixed and are increased so that the ratio has fixed values: 0, 1/6, 1/3, 1/2, and 1, corresponding to Lode angles of and . The analysis is based on a modified form of the Matsuoka–Nakai/Lade–Duncan condition, employed earlier by Haimson and Rudnicki [3] for the prediction of fault angle:

where . is determined by the mean stress dependence in deviatoric pure shear ( ). controls the shape of the failure surface in deviatoric planes: For the shape is circular, as for a Drucker-Prager material; for , the shape is triangular, as for a Rankine material. Dependence of on allows changes of shape of the failure surface with mean stress.

For both sandstones, data for are well-fit by a quadratic function for . Data for the Coconino are consistent with a positive slope for whereas those for the Bentheim sandstone suggest a peak in the curve. The dependence of on is determined from the values calculated for . For both sandstones is approximated by a bi-linear function of . For the Coconino remains positive in the range of the data but for the Bentheim becomes negative for greater than about 180 MPa. This feature appears to be related to the peak in the curve. Curves calculated for at other values of fit the data well. These forms for and are used with the above criterion to calculate results for conventional true triaxial tests and compare with observations. The calculated results exhibit the typical behavior that at failure for fixed increases to a peak and then decreases with increasing . Agreement with the data is generally good, although less so for axisymmetric stress states.

REFERENCES

[1] Ma, Haimson, *Abstract T33C-2435, 2011 Fall Meeting*, AGU, San Francisco, California, 2011.
[2] Ma, Rudnicki, Haimson, *Geophysical Research Abstracts*, Vol. 16, EGU2014-1800-1, 2014.
[3] Haimson, Rudnicki, *Journal of Structural Geology*, 2010.